Knudsen, Brian. 1983

General Ungulate Model: User's Manual. Version 1.0.

MANITOBA
DEPARTMENT OF NATURAL RESOURCES
Wildlife Branch
Biological Services

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Department of Natural Resources,
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ABSTRACT

The General Ungulate Model allows wildlife biologists to conduct simulations of the dynamics of ungulate populations. Data required to run the model are the size and age structure of the population, reproductive rates, and numbers of animals lost to each source of mortality acting on the population. The maximum period which can be simulated is 8 years. The model runs on an Apple computer, and emphasizes speed, ease of use, and graphical demonstration of results. It is suitable for workshop applications or for presentations to groups.

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If this model proves to be useful, it will be because of the contributions of a number of people who have been interested in the creation of practical models for wildlife management. Dave Fulton wrote the majority of a large APL model (SNOWDEER), from which many of the interactive principles of this model were derived. Herb Goulden provided the spark which began simulation on small computers when he encouraged me to write a simple deer model for a symposium. Dick Robertson and Vince Crichton provided valuable criticism of earlier models and promoted their use in discussions with game and fish organizations and with Treaty Indian hunters.

Dwain Davies has run this model innumerable times, finding bugs, suggesting improved formats, and verifying the biology. His patience, assistance, and data have been invaluable.

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INTRODUCTION

The management of herds of wild ungulates requires some ability to forecast changes in the abundance and composition of the herds. Preparing such forecasts manually is so laborious that the job is rarely done properly and often is not done at all. Fortunately, the small computers which have now become accessible to the general public are ideally suited to this task. A program can be written to carry out the repeated calculations which represent the annual processes of birth, aging, and death. Such a program, called a model, performs thousands of calculations per second. With this computing capability, a biologist can evaluate the consequences of a number of alternative management strategies in a very short period of time. The results can be used in a number of contexts, such as:

a) presentation of data to groups which use the ungulate herd in question,
b) presentation of data to senior management personnel, or
c) incorporation of forecasts into annual reports, work outlines, or project proposals.

The General Ungulate Model is intended to serve the immediate needs of working wildlife managers. The model is NOT intended to investigate basic ecological relationships. There are no inter-related processes such as density-dependent birth and death rates in the model. The assumptions of the model and requirements of the system are as follows:

1. The user has an Apple II Plus computer with 48K of memory, a video display of some kind, and at least one disc drive. A printer is useful but not necessary. (Epson MX-80 and MX-100 printers give correct printouts. Other brands may not.)

2. The species has an annual schedule of reproduction.

3. The species does not have a significant proportion of the population surviving beyond 10 years of age.

4. The species is not limited by the quality of its forage.

5. The species is polygynous.

6. The user does not want to simulate a period of more than eight years.

7. The user has the following data available:
   a) the number of animals in the herd
   b) the age and sex structure of the herd
   c) the survivorship of newborn animals to age six months
   d) the number of animals lost to each source of mortality
   e) the relative vulnerability of age and sex classes to each mortality factor

f) the age-specific reproductive rates of females.

In many cases the population dynamics of the herd will be insensitive to some of the biological data, and simulations can be run with approximations of those data. The user may have to collect detailed information on a particular aspect of the herd's biology before being able to conduct useful simulations. Only repeated trial simulations will tell which of these alternatives applies in a given case. Users wishing to pursue this topic in detail will find that it is usually discussed under the heading of sensitivity analysis.

RUNNING THE MODEL

Starting Up

Learn how to use an Apple and its disc drive without destroying anything.

Put the General Ungulate Model in the disc drive and close the door. If the system has more than one drive, be sure that the drive you use is labelled DRIVE 1 and is connected to slot 6 inside the machine. Turn on the Apple, screen, and printer (if present).

After some whirring and clicking, you should see a message which tells you that you are running the General Ungulate Model. You will then be asked the number of the Game Hunting Area (GHA) you wish to simulate. (This is just a convenient arrangement for using the model in Manitoba. Other organizations wishing to use this model

efficiently will have to spend some time creating copies of the model, with appropriate names and with defaults - data which are loaded automatically when the model is started.) After you have typed in the correct number, press RETURN. While the program is being loaded (more whirring and clicking), the red light on the front of the disc drive will be on. DON'T TOUCH ANYTHING WHILE THAT LIGHT IS ON! When the light is off you are ready to run the model.

Check the version number displayed on the screen and make sure it matches the version number on the front page of this manual. If the versions are not the same, turn off the machine and find a manual and disc which have the same version number. I am recommending this cautious procedure because I have no way of knowing what changes will be made as successive revised versions appear. Some differences among versions could generate serious and hidden errors for unaware users.

If the versions match, follow the instructions for proceeding (PRESS ANY KEY). There will be a pause of a second or two while a few housekeeping chores are performed within the model.

Specifying Parameters

Setting Printout Parameters

The first questions you will be asked will be about the printout you want from this simulation. The title page contains information as shown in Fig. 1. If you want a title page, enter Y in response to the prompt. Do not press RETURN. In this model, to save keystrokes, you do not have to press RETURN when only one character (for example Y or N) is required by the program. If more than one character might be entered in response to a prompt, then the entry has to be completed by pressing RETURN.

After you have specified whether you want a title page, you will be asked whether you want a printout after each year of simulation. Each annual printout contains the information as in Fig. 2. If you want an annual printout, enter Y again.

Should you run the model more than once in a session, the sequence of printout parameter prompts will begin again. If you don't want to change anything about the printout from a previous run, just enter (SHIFT) > in response to the first prompt. The second prompt will be skipped and you will go straight to the main setup menu.

```
**********************************************
*                                            *
*   GENERAL UNGULATE MODEL, VERSION 1.0      *
*                                            *
**********************************************

SPECIES:
NAME OF HERD:
DATE:
USER:
TITLE:                    BHA 8

==============================================================================

PARAMETERS AS SET FOR THIS RUN:

    CONTINUOUS APPLICATION OF THE SAME MORTALITY RATES?          YES
    STARTING YEAR:                                              1982
    NUMBER OF YEARS:                                               2

    PROPORTION OF THE CALF CROP (AT BIRTH) WHICH IS MALE:         .5
    PROBABILITY OF SURVIVING FIRST SIX MONTHS OF LIFE:            .45
    UNRETRIEVED KILL, AS A PROPORTION OF RETRIEVED KILL:          .1

    APPLICATION OF MORTALITY FROM:

                                  WOLVES:          WEIGHTED
                                  TREATY:          PROPORTIONAL
                                  WINTER:          DELETED
                                  BLACK BOX:       PROPORTIONAL
                                  SPORT HUNTING:   PROPORTIONAL

==============================================================================

COMMENTS:
```

Fig. 1. A sample of the title page printed by the General Ungulate Model.

```
BHA 8:    SUMMARY OF 1982

                BULLS  COWS CALVES TOTAL

YEAR START:       100   260    132   500
MEAN AGES   MALES: 3.67  FEMALES:  4.18

LOSSES TO:
   WOLVES          18    22     45    85
   TREATY KILL     16    42     15    73
   WINTER KILL      0     0      0     0
   BLACK BOX        3     8      3    14
   SPORT KILL      27     0      0    27
   POSTNATAL        0     0    102   102

  TOTALS           64    72    165   301

YEAR END:         77   216     80   373
MEAN AGES   MALES: 3.67  FEMALES:  4.49
CALVES/100 COWS ...AT BIRTH:        82.9
                ...6 MONTHS:        37.3

                *****

BHA 8:    SUMMARY OF 1983

                BULLS  COWS CALVES TOTAL

YEAR START:       77   216     80   373
MEAN AGES   MALES: 3.67  FEMALES:  4.49

LOSSES TO:
   WOLVES          18    22     45    85
   TREATY KILL     15    50      9    74
   WINTER KILL      0     0      0     0
   BLACK BOX        1     9      3    13
   SPORT KILL      27     0      0    27
   POSTNATAL        0     0     81    81

  TOTALS           61    81    138   280

YEAR END:         28   147     62   237
MEAN AGES   MALES: 4.00  FEMALES:  5.14
CALVES/100 COWS ...AT BIRTH:        94.7
                ...6 MONTHS:        42.6
```

Fig. 2. A sample of the annual printout produced by the General Ungulate Model.

The Main Setup Menu

This is the part of the model from which you gain access to all the small portions (subroutines) of the model which display and allow you to modify the parameters used by the model (Fig. 3). When the main setup menu is on the screen, you just press the appropriate number, from 0 (finished with the menu) to 6. Since only one character is required, this is one of the cases where you should not press RETURN. If you press a key which is anything other than the numbers 0 to 6, you will be reprimanded by a beep and a clean menu. This should always happen when you give the model a nonsensical response. If you find a place in the model where you can enter nonsense without getting a beep, note it and let me know.

Setting the Title (Main Menu Option 1)

It will often be useful to have a title displayed on the screen which reminds you of the purpose or details of the simulation while it is occurring or while you are setting up. For example, if you are modeling the response of a herd in GHA 18 to a closed season, you might enter the title "CLOSED18". The title is limited to 10 characters. Ten characters don't allow for elaborate titles, but you can fill in lots of detail manually on the title page.

If you have pressed 1 by mistake, and don't really want to reset the title, just press (SHIFT)) and RETURN to get back to the main setup menu.

```
GHA 8:  MAIN SETUP MENU
---------------------------------------

WHAT DO YOU WANT TO CHANGE OR CHECK?


  1.  TITLE
  2.  STARTING POPULATION
  3.  REPRODUCTIVE RATES
  4.  AGE DISTRIBUTION
  5.  MORTALITY FACTORS
  6.  SINGLE PARAMETER VALUES

  Ø.  FINISHED WITH MENU

ENTER THE APPROPRIATE NUMBER:  Ø
```

Fig. 3. The main setup menu.

Setting the Starting Population (Main Menu Option 2)

If you press 2, the default starting population for this GHA will be displayed. If you don't want to change this, just press (SHIFT) > and you will get back to the main setup menu.

If you want to change something, press 1, 2, or 3 to specify changing bulls, cows, or calves, respectively. A prompting arrow will appear beside the category you chose. Enter the number of animals in the category and press RETURN. When the numbers are as you want them, press (SHIFT) >.

Setting the Age-specific Reproductive Rates (Main Menu Option 3)

This is one of many situations in which you are shown a list of numbers instead of a single number. In this case you see a column of 10 age classes and the mean number of calves per cow for each class. Note that in this model, age class 1 is calves, age class 2 is yearlings, etc.

The number of calves per cow is the number of young actually born. There is no incorporation of postnatal mortality into these data. In most cases, the mean number of fetuses per cow is the best estimator. If the default age-specific reproductive rates are satisfactory, press (SHIFT) > and you will be back at the main setup menu.

If you want to revise the list, press (SHIFT) *. You will see a prompting arrow at the reproductive rate for class 1. Enter the number for this class and press RETURN. The arrow will go to the rate for class 2. Keep going this way until you have fixed the list the way you want it. Then press / if you want the list displayed for approval. If you need more revisions, press (SHIFT) * again. If

everything is OK, press (SHIFT)).

Setting the Starting Age Distribution (Main Menu Option 4)

If you press 4 when the main setup menu is displayed, you will be shown the starting age distribution for males in classes 2 to 10. (Class 1 has already been specified in the CALVES section of the starting population, so ignore the 0 for that class.) If you want to revise this distribution, press (SHIFT) * as you did with the age-specific reproductive rates, and proceed to fill in the proportions as desired, pressing RETURN after each proportion. As with reproductive rates, when you want to have the list displayed, enter / instead of a number. In this list, and all lists further down the main setup menu, the total of the list of proportions is printed below and to the right of the list. This allows you to make sure that the proportions you have entered sum to 1.000. If the list doesn't sum to 1.000, press (SHIFT) * and fix it. When everything is OK, press (SHIFT)).

Note that you are not returned to the main setup menu by (SHIFT) in this case, but instead you are shown another list: the starting age distribution for females. Handle this list as you did the age distribution for males. When you are finished with the female age distribution, (SHIFT)) will get you back to the main setup menu.

Setting the Status of Mortality Factors (Main Menu Option 5)

If you choose option 5 from the main setup menu, you will be shown a secondary menu which lists the five categories of mortality handled by the model, and the way in which they are handled by default (Fig. 4).

```
GHA 8:  MORTALITY FACTORS
----------------------------------------

HERE IS THE STATUS OF MORTALITY FACTORS:
      FACTOR      DISTRIBUTION

  1.  WOLVES      WEIGHTED
  2.  TREATY      PROPORTIONAL
  3.  WINTER      DELETED
  4.  BLACK BOX   PROPORTIONAL
  5.  HUNTING     PROPORTIONAL
           ( > TO EXIT)
```

Fig. 4. The mortality menu.

Beside each factor there can be one of three alternative methods of application:

1. Weighted. If the mortality factor is specified as weighted, the factor is not random in its action. That is, some age or sex classes are weighted, or more vulnerable to that factor. A simple example is the way in which predation often takes a disproportionately large number of animals from age class 1 (calves). For example, 50% of the loss to wolves might be calves, even if only 25% of the population were calves. To carry out this method of imposing mortality, the model requires a list of weights. These weights will be described below.

2. Proportional. If the mortality factor is proportional, it means that age classes are subjected to this factor in proportion to their abundance. For example, if females in age class 4 constitute 15% of the total population, a mortality factor acting on the total population and causing the death of 100 animals would contain 15 females from class 4. Using this method of imposing mortality does not require entering a list of weights.

3. Deleted. If you do not want to apply a mortality factor, you can specify that it be deleted from the simulation.

Enter the number of the factor you wish to examine or modify (1 to 5). You will be presented with the three alternatives as listed above. Choose the one you want.

If you choose 1 (weighted), you will see a list like the one you encountered with reproductive rates and age distributions. Most likely, it will be zeros, so start to fill it in ((SHIFT) *). Be careful in entering these weights, remembering that, for example, if you put 0.21 beside an age class, 21% of all of the animals killed by that mortality factor will be taken from that class of sex and age.

When you are dealing with these factors, remember that it is not each list that must total 1.000, but the sum of the male and female lists of weights for each factor.

NOTE: The exception to this rule is Hunting. In Hunting, males and females are treated separately, and each list of weights must sum to 1.000.

If you choose options 2 or 3, you'll go straight back to the main mortality menu.

For a description of the meaning of each mortality factor, and of the way in which the calculations are handled when mortality is being imposed, see options 5 to 11 in the menu for setting the values of single parameters (below).

When you have specified all 5 mortality factors to your satisfaction, and have the main mortality menu on the screen, enter (SHIFT)). You will return to the main setup menu.

Setting the Values of Single Parameters

By choosing option 6 from the main setup menu, you enter a secondary menu which allows you to set individual values required by the model (Fig. 5). To modify a value, enter the number shown beside it. Note that because some numbers contain 2 digits, RETURN is required to complete the entry.

GHA 8: SINGLE PARAMETERS

	PARAMETER	STATUS
1.	CONTINUOUS	YES
2.	CALVES BORN: MALES/TOTAL	.5
3.	CALVES: 6 MONTHS/BORN	.45
4.	UNRETRIEVED/RETRIEVED	.1
5.	HUNTING KILL: CALVES/TOTAL	Ø
6.	HUNTING: MALES KILLED	25
7.	HUNTING: FEMALES KILLED	Ø
8.	WOLVES: TOTAL KILL	90
9.	TREATY HARVEST: TOTAL KILL	75
10.	WINTER WEATHER: TOTAL KILL	Ø
11.	BLACK BOX: TOTAL KILL	15
12.	STARTING YEAR	1982
13.	YEARS OF SIMULATION	5
14.	PAUSE AFTER EACH YEAR?	YES
Ø.	NO FURTHER CHANGES	

Fig. 5. The single parameter menu.

Single Parameter Option 1 - CONTINUOUS

This value specifies whether the same losses to each mortality factor are to be repeated continuously throughout the simulation. If this is set to YES, each year of simulation will progress without any input from the user. If this is set to NO, the model will ask the user for the loss to each mortality factor as that factor arises in each annual cycle.

Single Parameter Option 2 - CALVES BORN: MALES/TOTAL

This specifies the sex ratio at birth. The default value is 0.5, meaning that the ratio is 50:50. If you have data to suggest some other ratio, this is where you put it in the model.

Single Parameter Option 3 - CALVES: 6 MONTHS/BORN

Every population of ungulates has a certain rate of postnatal mortality, in which newly-born young die for many reasons, including sickness, exposure, and predation by opportunistic predators which do not pose a threat to post-juvenile members of the species. This postnatal mortality is most easily measured by comparing the number of fetuses per cow with the number of young per cow during mid-winter aerial surveys. The ratio of these two numbers, calculated as above, gives the probability of surviving the first 6 months of life. This is a critical component in many simulations. If you have set

CONTINUOUS to NO, each year you will be asked if you want to change the survivorship of calves during that year.

Single Parameter Option 4 - UNRETRIEVED/RETRIEVED

Data on the success of hunters tend to deal only with animals which were retrieved by the hunters, and yet it is known that the actual number of animals killed by hunters is higher than this. In some studies, the unretrieved kill has been found to be as high as 50% of the retrieved kill. This is extremely difficult to measure in many cases, and often an estimate has to be used. The default value is 0.1, meaning that the unretrieved kill is 10% of the retrieved kill.

Single Parameter Option 5 - HUNTING KILL: CALVES/TOTAL

The data in Manitoba which summarize the age and sex structure of the kill by licenced hunters have usually included the proportion of the kill which is calves. By specifying this proportion users can weight hunting mortality with respect to calves only, leaving the other age classes to be taken in proportion to their abundance. In a season which allows only adult males to be killed, this parameter should be set to zero.

Single Parameter Option 6 - HUNTING: MALES KILLED

This parameter is straightforward: enter the number of males

killed and retrieved by hunters. This figure, multiplied by the unretrieved kill proprortion, produces the unretrieved kill of males. The unretrieved kill is added to the retrieved kill to generate the total number of males killed by licenced hunters.

Single Parameter Option 7 - HUNTING: FEMALES KILLED

Use this option as you used Single Parameter Option 6.

Single Parameter Option 8 - WOLVES: TOTAL KILL

This Single Parameter Option operates as do Single Parameter Options 6 and 7, but without any unretrieved kill being added to the kill which was entered.

Single Parameter Option 9 - TREATY HARVEST: TOTAL KILL

In version 1.0, the Treaty harvest is calculated as in the kill by wolves; that is, no unretrieved kill is calculated.

Single Parameter Option 10 - WINTER WEATHER: TOTAL KILL

This mortality factor is imposed as are Treaty kill and wolf kill. Note that the number of animals entered as dying from winter

weather should be the number actually killed during the winter. If the consequence of a bad winter is visualized as being low survival of calves born after the winter, then the mortality should not be entered as a winter weather kill, but as a lower probability of calves' surviving the first 6 months of life (Single Parameter Option 3).

Single Parameter Option 11 - BLACK BOX: TOTAL KILL

This category includes a number of sources of mortality which are usually difficult or impossible to measure. They include poaching, accidents, disease, and parasites. The relative contribution of each of these components will vary with the species and location of the herd being simulated. For example, a dense deer herd near an urban area will probably have accidents as a large component of black box mortality. A deer herd in an isolated agricultural area would be likely to suffer more from poaching than from accidents. A moose herd in a remote area, far from white-tailed deer range, would probably be subjected to very little black box mortality of any kind.

Single Parameter Option 12 - STARTING YEAR

This is the first complete year of simulation. The starting population entered from option 2 of the main setup menu would be the population as of 1 January of this year.

Single Parameter Option 13 - YEARS OF SIMULATION

This is the total number of complete calendar years to be simulated. If you specify a simulation of 5 years, your output will present the status of the population at 6 times: 1 January of each of the 5 years, starting with the starting year, and also 1 January of the year after the simulation finished, so that the final consequence of the simulation can be seen.

Single Parameter Option 14 - PAUSE AFTER EACH YEAR?

If you want to study the results of each year's simulation carefully during the run, set this option to YES. You can do this by entering Y, YES, or any other response beginning with Y. If you do this, the model will ask you to press any key after it has displayed a table or graph during the run. The table or graph will remain on the screen indefinitely if you don't press a key. If you do not want to have to keep pressing keys to have the simulation proceed, set this option to NO, by entering N, NO, or any other word beginning with N. This will cause the model to pause for 2 or 3 seconds after a table or graph is displayed, and then proceed. This feature is useful if you

have a title page and annual tables printed during the run. You can start the simulation, leave the machine running while you attend to some other task, and come back later to find the last graph displayed on the screen and all the annual tables printed for you. If you are nearby, you will hear 3 beeps to let you know the simulation is finished. At that time, you will be asked if you want a summary table printed (Fig. 6). Enter Y or N, as appropriate. Don't press RETURN.

Single Parameter Option 0 - NO FURTHER CHANGES

When you have set all the variables in this menu as desired, enter 0 and press RETURN. You will be returned to the main setup menu.

Starting the Simulation (Main Menu Option 0)

This is the option in the main setup menu which begins the simulation. After you have entered 0, you will first be given the opportunity to abort the simulation. The abort option is in the model to catch the simulation if you have entered 0 in error. If you want to stop here and go back to the main setup menu to revise something, just press A. If everything is set and you really want to start the run, press any other key.

THIS IS A SUMMARY OF THE SIMULATION

YEAR *	BULLS	COWS	CALVES	TOTAL
1982	108	260	132	500
1983	77	216	80	373
1984	28	147	62	237

* ALL NUMBERS ARE AS OF 1 JANUARY

Fig. 6. The table which summarizes the simulation.

TROUBLESHOOTING

Stopping a Run

There will be times when you will want to stop a run before it is finished. You may have set a parameter incorrectly, or you may be able to see the result you wanted after only 2 or 3 years of an 8 year simulation. To stop the program and return to the main setup menu for another run, hold down the control key (CTRL) and press C. This is the standard command for stopping an Apple program. In this model, instead of completely stopping the program, you skip to the resetting of variables and have the opportunity of running another simulation.

If you want to quit completely, wait for the printout specification prompt to appear. Then, as the appropriate prompts appear, enter the following sequence of responses:

(SHIFT) > to get to the main menu

0 to leave the menu

A to abort the run

N to avoid another run

Q to confirm that you want to quit.

Recoverable Crashes

There will be occasions when the program will encounter some type of problem that will cause it to stop (or bomb, or crash). In some cases, a crash-trapping subroutine in the model will catch the problem and display a complete message (Fig. 7), which will allow you to record an error number (useful in correcting problems causing some types of crashes), and press any key to proceed. This type of crash is inconvenient, but does not cost the user much time.

Non-recoverable Crashes

Sometimes the crash-trapping subroutine will be tricked by a problem arising during a run, and the crash will be considerably less convenient. The display can take many forms in such an event. Part of the recovery message might be printed, and the keyboard might go dead. The computer might completely leave the language, and display a series of asterisks and numbers. When something like this occurs, you will have to restart the model. If you turn the machine off and then on, you will be certain of getting yourself operational again, but it will take a few minutes.

There is a faster way to restart the program: press the RESET button, then type RUN (RETURN). The model should restart in a second or two. This fast restart will only work if the crash did not erase a large segment of memory. It will be immediately obvious whether the fast restart is working or not. (This is the only time you should ever touch the RESET button!)

```
GHA 8:  ERROR HANDLING
----------------------------------------

CONGRATULATIONS, PAL.

ONE OR BOTH OF THE FOLLOWING HAS/HAVE
HAPPENED:


1.  YOU SCREWED UP.

2.  I SCREWED UP.

IN ORDER TO ALLOW ME TO TRACK DOWN THE
SCREWUP (AND THE PERSON RESPONSIBLE)
PLEASE WRITE DOWN THE CIRCUMSTANCES
PRECEDING THE BUNGLE, AND THE FOLLOWING
NUMBER:          77 .
THIS IS THE ERROR CODE FOR WHAT YOU/I
JUST DID.  TO CARRY ON, PRESS ANY KEY.
```

Fig. 7. The display which appears on the screen when the program has been stopped unintentionally.

APPENDIX: PROGRAM LISTING

The following listing is a representative copy of version 1.0 of the General Ungulate Model. Copies differ only in the default values, assigned in the first 100 lines of the program. As a rule, subroutines start on lines which are even multiples of 100. The only exception to this is the little subroutine starting on line 150. The main program starts on line 5000, and accesses subroutines located earlier in the program. (A program runs considerably faster when subroutines which are used frequently are placed near the top of the program.)

Each subroutine starts with a REM statement which indicates the subroutine's purpose. At the end of a subroutine, there are usually 2 REM statements which act as spacers to make the program more readable. These lines usually end in 95 and 96.

The extensive internal documentation makes the program easier to read, and is therefore useful for new users, especially those who wish to change the model. REM statements take up a lot of room, however, and it is useful to have a crunched version - one with the REM statements removed. If you decide to crunch the model, be careful not to delete REM statements which are addressed in GOSUB or GOTO statements. Deleting those lines will cause the program to bomb.

Software is available (such as in the Applesoft Tool Kit), which will crunch the program for you, and check for GOSUB and GOTO addresses. If a REM line is addressed, the Tool Kit will delete all the notation on the line, but will leave the line number and the REM command, so that as much space as possible is saved while ensuring that the program will still run.

```
]LIST

1  REM  PROGRAM NAME - GENERAL UNGULATE MODEL
2  REM  AUTHOR:  BRIAN KNUDSEN, WILDLIFE BRANCH, DEPARTMENT OF NATURAL RESO
URCES, 1495 ST. JAMES ST., WINNIPEG, MANITOBA
3  REM  ---------------------------
4  REM   DEFAULT GHA:.....................................
5  REM  DATE OF LISTING:..................................
6  POKE 33,40: PR# 0
7  GOSUB 1500: REM  STARTUP MESSAGE
10  REM  INITIALIZE VARIABLES AND DEFINE FUNCTIONS
12  DEF  FN A(X) = 0.1 *  INT (X * 10): REM  ONE DECIMAL PLACE
14  DEF  FN B(X) = 0.01 *  INT ((X + .005) * 100): REM     TWO DECIMAL PLAC
ES - ROUNDED
15  DEF  FN C(X) = (X >  = 0) * X: REM  X WILL NEVER BE NEGATIVE
16 LMARGIN = 0:WWIDTH = 40:TWINDOW = 0:BWINDOW = 24: GOSUB 300: REM  SET  F
ULL SCREEN
17  DEF  FN D(X) =  LEN ( STR$ (X)): REM  TOTAL NUMBER OF CHARACTERS IN A N
UMBER
18 ZERO = 0:HALF = .5:UN = 1:DEUX = 2:DIX = 10: REM  USE FOR ZERO,HALF,ONE,
TWO, AND TEN TO INCREASE SPEED
19  DEF  FN E(X) = .001 *  INT (X * 1000): REM  THREE DECIMAL PLACES
20 CF = 400:BB = 600:CD = 800: REM    CALVES OR FAWNS, BULLS OR BUCKS, COWS
 OR DOES
22 MA = 800:FE = 1000: REM     TOTAL MALES AND FEMALES
24 ST(1) = BB:ST(2) = CD:ST(3) = CF:ST(4) = MA:ST(5) = FE: REM  STORAGE OF
THE FIVE STARTING ABUNDANCES
25  REM
26  DATA     0,.28,.22,.2,.12,.09,.05,.02,.01,.01                : REM    AG
E DISTRIBUTION OF BULLS/BUCKS - ZERO IS FILLER
28  DATA   0,.25,.18,.12,.09,.08,.08,.07,.07,.06                   : REM  A
GE DISTRIBUTION OF COWS/DOES - ZERO IS FILLER
30  FOR I = UN TO DIX: READ MD(I): NEXT
32  FOR I = UN TO DIX: READ FD(I): NEXT
33  REM
34 SL =  - 16336: REM  SPEAKER LOCATION
36  FOR I = UN TO 5:HV(I) = ZE: NEXT : REM  FIVE HOLDING VALUES TO PARALLEL
 THE ST SERIES
38  DATA   0,.5,1.3,1.3,1.9,1.9,1.9,1.9,1.3,1.0: REM  AGE-SPECIFIC REPRO RA
TES
40  FOR I = UN TO DIX: READ RR(I): NEXT : REM  AGE-SPECIFIC BIRTH RATES
42 MPRCNT = HALF: REM   PROPORTION OF MALES IN CALF CROP AT BIRTH
44 CC(UN) = ZE:CC(DE) = ZE: REM  CALVES PER 100 COWS AT BIRTH AND AFTER SIX
 MONTHS
46 PSTNT = 0.45: REM        ULTIMATE SURVIVORSHIP OF CALVES FROM BIRTH TO S
IX MONTHS (110 TO 50 CALVES PER 100 COWS)
48 PNLOSS = ZE
50 URKILL = 0.10: REM  UNRETRIEVED KILL
52 HM = ZE:HF = ZE: REM   MALE AND FEMALE RETRIEVED HUNTING KILL
54 HCPRCNT = 0.06: REM    PROPORTION OF THE LICENCED KILL WHICH IS CALVES

56 MHUNT(UN) = ZE:FHUNT(UN) = ZE: REM  DUMMY VALUES OF ZERO FOR THE FIRST E
LEMENTS IN THE WEIGHTING OF MORTALITY FROM LICENCED HUNTING
58 EDIST = UN / 9
60  FOR I = DEUX TO DIX:MHUNT(I) = EDIST:FHUNT(I) = EDIST: NEXT : REM  EVEN
 DISTRIBUTION OF KILL WITH RESPECT TO AGE
62 MA(UN) = MPRCNT * CF:FE(UN) = CF - MA(UN)
```

```
64  FOR I = DE TO D1:MA(I) = BB * MD(I):FE(I) = CD * FD(I): NEXT
66 WP$(UN) = "WEIGHTED":WP$(DEUX) = "PROPORTIONAL":WP$(3) = "DELETED"
68 WOLFLAG = UN:TFLAG = DEUX:WEAFLAG = 3:BFLAG = DEUX:HUFLAG = DEUX: REM
 ALL FLAGS SET TO PROPORTIONAL DISTRIBUTION OF MORTALITY EXCEPT WOLVES AND
WEATHER
70 YN$(0) = "NO":YN$(1) = "YES"
71 CNT = UN:YPFLAG = UN: REM    SET DEFAULT TO CONTINUOUS, WITH PAUSE AFTER
 EACH YEAR
72 SYEAR = 1974
74 TYEARS = 8
76  DATA    .18,0,0,0,0,0,0,0,0,0                  : REM   WEIGHTS FOR WOLF MO
RTALITY ON MALES
78  FOR I = UN TO DIX: READ WM(I): NEXT
80  DATA     .18,.01,.02,.03,.02,.05,.07,.11,.15,.18: REM  WEIGHTS FOR WOLF
 MORTALITY ON FEMALES
82  FOR I = UN TO DIX: READ WF(I): NEXT
83 FFFLAG = 0: REM  FORM FEED FLAG
84  DIM OM(10,9,4)
86 WKILL = 50:TKILL = 0:HM = 200:HF = 90:BKILL = 25: REM      SPECIAL SETTI
NG OF DEFAULTS FOR AREA 18
88  DIM ML$(11): REM  MORTALITY LABELS
89 ML$(2) = "WOLVES":ML$(3) = "TREATY KILL":ML$(4) = "WINTER KILL":ML$(5) =
 "BLACK BOX":ML$(6) = "SPORT KILL":ML$(7) = "POSTNATAL"
94  ONERR  GOTO 3300
95  GOTO 5000: REM  START OF MAIN PROGRAM
96  REM
97  REM
98  REM
99  REM
100  REM  SBR TO CALCULATE TOTALS AND MEAN AGES
102  REM
104 MA = ZE:FE = ZE:CF = ZE:BB = ZE:CD = ZE:MCUM = ZE:FCUM = ZE:MMAGE = ZE:
FMAGE = ZE: REM  INITIALIZE ALL COUNTERS TO ZERO
106  FOR I = DE TO DIX:BB = BB + MA(I):CD = CD + FE(I):MCUM = MCUM + ((I -
HALF) * MA(I)):FCUM = FCUM + ((I - HALF) * FE(I)): NEXT
108 CF = MA(UN) + FE(UN):MA = MA(UN) + BB:FE = FE(UN) + CD
109  IF  NOT (BB * CD * CF) THEN 115
110 MMAGE = MCUM / BB:FMAGE = FCUM / CD: REM  MEAN AGES ARE CALCULATED WITH
OUT CALVES/FAWNS AND ARE TAKEN AS IF IN THE MIDPOINT OF THE YEAR CLASS (LAT
E FALL)
112  GOTO 120
115  PRINT "ONE CATEGORY HAS GONE TO ZERO": GOTO 6000
120  RETURN
125  REM
126  REM
150  REM  SBR TO HOLD VALUES OF POPULATION STATUS
152  REM
154 HV(UN) = BB:HV(DE) = CD:HV(3) = CF:HV(4) = MA:HV(5) = FE
156  RETURN
195  REM
196  REM
200  REM  SBR FOR AUDIBLE SIGNAL TO USER
202  REM
204  FOR BEEP = UN TO 30:X =  PEEK (SL): NEXT
206  RETURN
295  REM
296  REM
300  REM  SBR FOR SETTING WINDOW
302  REM
304  POKE 32,LM: POKE 33,WW: POKE 34,TW: POKE 35,BW
```

```
306  RETURN
395  REM
396  REM
400  REM  SBR TO CHECK FOR NUMERICAL INPUT
402  REM
403 BUM = UN: IF  LEN (HOLD$) = 0 THEN  GOTO 420: REM    FLAG WILL BE SET T
O ZERO IF INPUT IS NUMERICAL
404  IF  LEN (HOLD$) = 1 THEN 406
405  IF ( LEFT$ (HOLD$,1) = ".") AND ( ASC ( MID$ (HOLD$,2,1)) > 47) AND (
ASC ( MID$ (HOLD$,2,1)) < 58) THEN 410
406  IF ( ASC (HOLD$) < 48) OR ( ASC (HOLD$) > 57) THEN 420
410 BUM = ZE: REM  FLAG NUMERICAL INPUT
420  RETURN
495  REM
496  REM
500  REM  SBR TO CHECK FOR NEXT STEP DURING INPUT
502  REM
504  REM      /  SIGNALS TO STOP PROMPTS FOR ENTRY AND DISPLAY STATUS OF DAT
A
506  REM        FOR ENTRY AND DISPLAY STATUS
508  REM      *  SIGNALS TO RESTART AN ENTRY ROUTINE
510  REM      >  SIGNALS TO EXIT THIS ENTRY ROUTINE
511  IF  LEN (HOLD$) = 0 THEN  GOTO 570
512 DSPLAY = ZE:RESTART = ZE:EXIT = ZE
520  IF HOLD$ = "/" THEN DSPLAY = UN: GOTO 560
530  IF HOLD$ = "*" THEN RESTART = UN: GOTO 560
540  IF HOLD$ = ">" THEN EXIT = UN: GOTO 560
550  GOTO 570: REM  VALUE OF BUM UNCHANGED
560 BUM = ZE
570  RETURN
595  REM
596  REM
600  REM  SBR TO PRINT TITLE AND OPERATION BEING PERFORMED
602  REM
604  VTAB 2: PRINT TITLE$;":  ";OP$
606  PRINT "----------------------------------------": PRINT
610  RETURN
695  REM
696  REM
700  REM  SBR TO DETERMINE METHOD OF APPLICATION OF MORTALITY
702  REM
704  HOME : GOSUB 600: REM   PRINT TITLE AND OPERATION
706  VTAB 6: HTAB 5: PRINT "HOW DO YOU WANT TO IMPOSE": HTAB 5: PRINT "MOR
ALITY FROM THIS SOURCE?"
708  PRINT : PRINT
710  HTAB 5: PRINT "1.  ACCORDING TO A LIST OF WEIGHTS"
712  HTAB 5: PRINT "    WHICH EMPHASIZES CERTAIN AGE OR"
714  HTAB 5: PRINT "    SEX CLASSES"
716  PRINT
718  HTAB 5: PRINT "2.  IN PROPORTION TO THE ABUNDANCE"
720  HTAB 5: PRINT "    OF EACH AGE OR SEX CLASS"
722  HTAB 5: PRINT "    WITHIN THE CLASSES BEING"
724  HTAB 5: PRINT "    INFLUENCED BY THIS FACTOR?"
725  PRINT : HTAB 5: PRINT "3.  DELETE THIS FACTOR FROM THIS": HTAB 5: PRIN
T "   SIMULATION."
726  PRINT
727  PRINT "ENTER 1, 2, OR 3:  ";
728  GET A$
730  IF (A$ = "1") OR (A$ = "2") OR (A$ = "3") THEN 748
732  GOSUB 200: REM  BEEP
```

```
734  CALL  - 868: GOTO 728
736  REM  NOTE THAT THIS SBR RETURNS THE NUMBER 1 OR 2 IN A$
748  PRINT A$
750  RETURN
795  REM
796  REM
800  REM   SBR TO DISPLAY STATUS DURING EXECUTION
802  REM
803  GOSUB 100: REM  COUNT
804  PRINT : PRINT "STARTING WITH:": PRINT "-------------"
806  PRINT  INT (BB);" BULLS,  "; INT (CD);" COWS,  "; INT (CF);" CALVES"
809  PRINT "TOTAL POPULATION:  "; INT (MA + FE)
810  PRINT "MEAN AGES   MALES: "; FN B(MMAGE);"  FEMALES:  "; FN B(FMAGE)
812 ZMMAGE = MMAGE:ZFMAGE = FMAGE: REM  HOLD MEAN AGES FOR PRINTOUT AT YEAR
END
890  RETURN
895  REM
896  REM
900  REM  SBR TO DISPLAY RESULTS GRAPHICALLY
902  REM
904  HOME : GR : COLOR= 12: REM   GREEN
906  FOR X = ZE TO 39: VLIN ZE,39 AT X: NEXT X
910  REM  HEIGHT OF SCREEN SET IN LINE 2852
912 SCFAC = 40 / MXP
914  FOR DY = ZE TO PL
916  COLOR= 2: REM  BLUE
918  VLIN 39, FN C((39 - SCFAC * OM(DY,9,1))) AT DY * 4
920  COLOR= 11: REM  PINK
922  VLIN 39, FN C((39 - SCFAC * OM(DY,9,2))) AT DY * 4 + 1
924  COLOR= 15: REM  WHITE
926  VLIN 39, FN C((39 - SCFAC * OM(DY,9,3))) AT DY * 4 + 2
928  NEXT DY
930  VTAB 21: HTAB 4: PRINT "FROM START OF " +  STR$ (SYEAR) + " TO END OF
" +  STR$ (CYEAR)
934  HTAB 3: PRINT "BLUE=BULLS  PINK=COWS  WHITE=CALVES"
936  PRINT " (THE GREEN AREA IS ";MXP;" ANIMALS HIGH)"
970  IF  NOT YPFLAG THEN 984
980  PRINT "PRESS ANY KEY TO CONTINUE....";: GET A$: PRINT A$
982  GOTO 988
984  FOR ZPAUSE = UN TO 1000: NEXT ZPAUSE
988  IF CYEAR = (SYEAR + TYEARS - 1) GOTO 990
989  TEXT : HOME
990  RETURN
995  REM
996  REM
1000  REM  SBR TO IMPOSE MORTALITY CAUSED BY WOLVES
1002  REM
1004  GOSUB 100: REM  RECALCULATE CURRENT STATUS OF THE POPULATION
1006  GOSUB 150: REM  HOLD VALUES FROM GOSUB 100
1008  REM  ROOM TO FORMAT THIS PROMPT
1010  IF CNT THEN 1020
1012  INPUT "KILLED BY WOLVES THIS YEAR:  ";WKILL: GOTO 1022
1020  HTAB 3: PRINT "IMPOSING WOLF MORTALITY"
1022  ON WOLFLAG GOTO 1060,1030
1030  REM  PROPORTIONAL MORTALITY
1032  FOR I = UN TO DIX
1034 MA(I) =  FN C(MA(I) - WKILL * MA(I) / (MA + FE))
1036 FE(I) =  FN C(FE(I) - WKILL * FE(I) / (MA + FE))
1038  NEXT I
1040  GOTO 1070
```

```
1050  REM
1060  REM  WEIGHTED MORTALITY
1062  FOR I = UN TO DIX
1064 MA(I) =  FN C(MA(I) - WKILL * WM(I))
1066 FE(I) =  FN C(FE(I) - WKILL * WF(I))
1068  NEXT
1070  GOSUB 100: REM  COUNT
1080  REM  CALCULATE LOSSES
1082 WLOSS(UN) = HV(UN) - BB: REM  BULLS/BUCKS
1084 WLOSS(DE) = HV(DE) - CD: REM  COWS/DOES
1086 WLOSS(3) = HV(3) - CF: REM  CALVES/FAWNS
1090  RETURN
1095  REM
1096  REM
1100  REM  SBR TO IMPOSE TREATY HARVEST
1102  REM
1104  GOSUB 100: REM  COUNT
1106  GOSUB 150: REM  HOLD
1108  REM  ROOM TO FORMAT
1110  IF CNT THEN 1120
1112  INPUT "KILLED IN TREATY HARVEST THIS YEAR:  ";TKILL: GOTO 1122
1120  HTAB 3: PRINT "IMPOSING TREATY KILL MORTALITY"
1122  ON TFLAG GOTO 1160,1130
1130  REM  PROPORTIONAL
1132  FOR I = UN TO DIX
1134 MA(I) =  FN C(MA(I) - TKILL * MA(I) / (MA + FE))
1136 FE(I) =  FN C(FE(I) - TKILL * FE(I) / (MA + FE))
1138  NEXT
1140  GOTO 1170
1150  REM
1160  REM  WEIGHTED
1162  FOR I = UN TO DIX
1164 MA(I) =  FN C(MA(I) - TKILL * TMWT(I))
1166 FE(I) =  FN C(FE(I) - TKILL * TFWT(I))
1168  NEXT
1170  GOSUB 100: REM  COUNT
1180  REM  CALCULATE LOSSES
1182 TLOSS(UN) = HV(UN) - BB:TLOSS(DE) = HV(DE) - CD:TLOSS(3) = HV(3) - CF
1190  RETURN
1195  REM
1196  REM
1200  REM  SBR TO IMPOSE WINTER MORTALITY
1202  REM
1204  GOSUB 100: REM  COUNT
1206  GOSUB 150: REM  HOLD
1208  REM  ROOM TO FORMAT
1210  IF CNT THEN 1220
1212  INPUT "KILLED BY WINTER WEATHER THIS YEAR:  ";KWNTR: GOTO 1222
1220  HTAB 3: PRINT "IMPOSING WINTER WEATHER MORTALITY"
1222  ON WEAFLAG GOTO 1260,1230
1230  REM  PROPORTIONAL
1232  FOR I = UN TO DIX
1234 MA(I) =  FN C(MA(I) - KW * MA(I) / (MA + FE))
1236 FE(I) =  FN C(FE(I) - KW * FE(I) / (MA + FE))
1238  NEXT
1240  GOTO 1270
1250  REM
1260  REM  WEIGHTED
1262  FOR I = UN TO DIX
1264 MA(I) =  FN C(MA(I) - KW * MWTH(I))
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1266 FE(I) =  FN C(FE(I) - KW * FWTH(I))
1268  NEXT
1270  GOSUB 100: REM  COUNT
1280  REM  CALCULATE LOSSES
1282 WEALOSS(UN) = HV(UN) - BB:WEALOSS(DE) = HV(DE) - CD:WEALOSS(3) = HV(3)
 - CF
1290  RETURN
1295  REM
1296  REM
1300  REM  SBR TO IMPOSE BLACK BOX MORTALITY
1302  REM
1304  GOSUB 100: REM  COUNT
1306  GOSUB 150: REM  HOLD
1308  REM  ROOM TO FORMAT
1310  IF CNT THEN 1320
1312  INPUT "KILLED BY BLACK BOX THIS YEAR:  ";BKILL: GOTO 1322
1320  HTAB 3: PRINT "IMPOSING BLACK BOX MORTALITY"
1322  ON BFLAG GOTO 1360,1330
1330  REM  PROPORTIONAL
1332  FOR I = UN TO DIX
1334 MA(I) =  FN C(MA(I) - BKILL * MA(I) / (MA + FE))
1336 FE(I) =  FN C(FE(I) - BKILL * FE(I) / (MA + FE))
1338  NEXT
1340  GOTO 1370
1350  REM
1360  REM  WEIGHTED
1362  FOR I = UN TO DIX
1364 MA(I) =  FN C(MA(I) - BKILL * MBBOX(I))
1366 FE(I) =  FN C(FE(I) - BKILL * FBBOX(I))
1368  NEXT
1370  GOSUB 100: REM  COUNT
1380  REM  CALCULATE LOSSES
1382 BLOSS(UN) = HV(UN) - BB:BLOSS(DE) = HV(DE) - CD:BLOSS(3) = HV(3) - CF
1390  RETURN
1395  REM
1396  REM
1400  REM  SBR TO IMPOSE HUNTING MORTALITY
1402  REM
1404  GOSUB 100: REM  COUNT
1406  GOSUB 150: REM  HOLD
1408  REM  ROOM TO FORMAT
1410  IF CNT THEN 1420
1412  INPUT "MALES IN LICENCED KILL:     ";HM
1414  INPUT "FEMALES IN LICENCED KILL:  ";HF: GOTO 1426
1420  HTAB 3: PRINT "IMPOSING LICENSED HUNTING ON MALES"
1422  HTAB 3: PRINT "                      ..... ON FEMALES"
1426 RM = (UN + URKILL) * HM:RF = (UN + URKILL) * HF: REM  INCORPORATE UNRE
TRIEVED KILL
1440  REM  IMPOSE MORTALITY ON CALVES
1442 CKILL = HCPRCNT * (RM + RF):KMCALF = CKILL * MA(UN) / CF:KFCALF = CKIL
L * FE(UN) / CF
1444 MA(UN) = MA(UN) - KMCALF:FE(UN) = FE(UN) - KFCALF
1446 RM = RM - KMCALF:RF = RF - KFCALF
1448  ON HUFLAG GOTO 1470,1450
1450  REM  PROPORTIONAL
1452  FOR I = DE TO DIX:MA(I) =  FN C(MA(I) - RM * MA(I) / BB):FE(I) =  FN
C(FE(I) - RF * FE(I) / CD): NEXT
1466  GOTO 1490
1468  REM
1470  REM  WEIGHTED
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1472  FOR I = DE TO DIX:MA(I) =  FN C(MA(I) - RM * MHUNT(I)):FE(I) =  FN C(
FE(I) - RF * FHUNT(I)): NEXT
1474  REM
1490  GOSUB 100: REM  COUNT
1492 HLOSS(UN) = HV(UN) - BB:HLOSS(DE) = HV(DE) - CD:HLOSS(3) = HV(3) - CF
1494  RETURN
1495  REM
1496  REM
1500  REM  SBR TO DISPLAY STARTUP MESSAGES
1502  REM
1504  HOME : VTAB 6: HTAB 4: PRINT "GENERAL UNGULATE MODEL, VERSION 1.0"
1506  HTAB 4: PRINT "-----------------------------------"
1508  VTAB 12: HTAB 14: PRINT "BRIAN KNUDSEN"
1510  PRINT : HTAB 9: PRINT "MANITOBA WILDLIFE BRANCH"
1512  PRINT : HTAB 12: PRINT "22 SEPTEMBER, 1982"
1580  VTAB 22: HTAB 8: PRINT "PRESS ANY KEY TO CONTINUE  ";: GET A$: PRINT
A$
1590  RETURN
1595  REM
1596  REM
1800  REM  SBR TO EXECUTE REPRODUCTION
1802  REM
1803  HTAB 3: PRINT "REPRODUCING"
1804 CALVES = ZE
1806  FOR I = UN TO DIX:CALVES = CALVES + FE(I) * RR(I): NEXT
1808  REM  ADVANCE AGE CLASSES
1810  FOR I = DIX TO DEUX STEP  - 1:MA(I) = MA(I - UN):FE(I) = FE(I - UN):
NEXT
1812 MA(UN) = MPRCNT * CALVES:FE(UN) = CALVES - MA(UN)
1820  GOSUB 100: REM  COUNT
1822 CC(UN) =  FN A(100 * CALVES / CD): REM  CALCULATE CALVES PER 100 COWS
AT BIRTH, ONE DECIMAL PLACE
1824  RETURN
1895  REM
1896  REM
1900  REM  SBR TO IMPOSE SIX-MONTH POSTNATAL MORTALITY
1902  REM
1903  HTAB 3: PRINT "IMPOSING POSTNATAL MORTALITY": GOSUB 100: REM   COUNT

1904  IF CNT THEN 1906
1905  GOSUB 3200: REM  CHECK TO ALTER POSTNATAL MORTALITY
1906 HV(3) = CF: REM  HOLD CALVES/FAWNS
1908 MA(UN) = PSTNT * MPRCNT * CALVES:FE(UN) = PSTNT * CALVES - MA(UN)
1909 CF = MA(UN) + FE(UN): REM  RECOUNT CALVES/FAWNS
1910 PNLOSS = HV(3) - CF: REM   LOSS TO UNSPECIFIED POSTNATAL MORTALITY
1912 CC(DEUX) =  FN A(100 * CF / CD): REM  CALVES PER 100 COWS AT SIX MONTH
S
1920  RETURN
1995  REM
1996  REM
2000  REM  MAIN SETUP MENU
2001  REM
2002 OP$ = "MAIN SETUP MENU": HOME : GOSUB 600
2004  VTAB 5: PRINT "WHAT DO YOU WANT TO CHANGE OR CHECK?"
2006  PRINT : PRINT
2008  PRINT "  1.  TITLE"
2010  PRINT "  2.  STARTING POPULATION"
2012  PRINT "  3.  REPRODUCTIVE RATES"
2014  PRINT "  4.  AGE DISTRIBUTION"
2016  PRINT "  5.  MORTALITY FACTORS"
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2018  PRINT "  6.  SINGLE PARAMETER VALUES"
2020  PRINT
2022  PRINT "  0.  FINISHED WITH MENU"
2023  PRINT
2024  PRINT "ENTER THE APPROPRIATE NUMBER:  ";: GET HOLD$
2026  PRINT HOLD$: GOSUB 400
2027  IF BUM THEN 2029
2028  IF  VAL (HOLD$) < 7 THEN 2040
2029  GOSUB 200: REM  BEEP
2030  VTAB ( PEEK (37)): CALL  - 868: GOTO 2024
2040  REM  ACCEPTABLE INPUT
2042 CHOICE =  VAL (HOLD$)
2044  IF  NOT CHOICE THEN 2080
2046  ON CHOICE GOSUB 2100,2200,2300,2400,2500,2600
2056  GOTO 2002
2080 OP$ = "ABORT OPTION": HOME : GOSUB 600: REM  TITLE
2082  VTAB 10: PRINT "   TO ABORT THE SIMULATION, PRESS   A."
2083  PRINT
2084  PRINT "PRESS ANY OTHER KEY TO BEGIN SIMULATION."
2086  VTAB 20: PRINT "->";: GET A$: PRINT A$
2088  IF A$ = "A" THEN 7000
2090  RETURN
2095  REM
2096  REM
2100  REM  SBR TO ALTER TITLE
2102  REM
2104 OP$ = "TITLE RESET": HOME : GOSUB 600
2105  VTAB 21: HTAB 12: PRINT "(ENTER  >  TO EXIT)"
2106  VTAB 8: INPUT "ENTER THE NEW TITLE:  ";HOLD$
2108  IF HOLD$ = ">" THEN 2190
2110  IF  LEN (HOLD$) <  = 10 THEN 2180
2120  GOSUB 200: REM  BEEP
2122  VTAB 15: PRINT "THE TITLE MUST BE 10 CHARACTERS OR LESS"
2124  VTAB 8: CALL  - 868
2130  GOTO 2106
2180 TITLE$ = HOLD$
2190  RETURN
2195  REM
2196  REM
2200  REM  SBR TO ALTER STARTING POPULATION
2202  REM
2204 OP$ = "STARTING POP REVIEW": HOME : GOSUB 600
2206  VTAB 6: PRINT "HERE IS THE CURRENT STARTING POPULATION:"
2208  VTAB 10: PRINT "  1.  BULLS:   ";BB
2209  PRINT
2210  PRINT "  2.  COWS:    ";CD
2211  PRINT
2212  PRINT "  3.  CALVES:  ";CF
2214  VTAB 21: HTAB 12: PRINT "(ENTER  >  TO EXIT)"
2216  VTAB 17: PRINT "TO CHANGE, ENTER 1, 2, OR 3 :     ";: GET HOLD$: PRIN
T
2218  GOSUB 400: REM  CHECK FOR NUMERICAL
2219  IF  NOT BUM THEN 2226
2220  GOSUB 500
2221  IF EXIT THEN 2290
2223  GOSUB 200: REM   BEEP
2224  GOTO 2216
2226  IF  VAL (HOLD$) > 3 THEN 2223
2228  IF  VAL (HOLD$) = 0 THEN 2223
2230  ON  VAL (HOLD$) GOTO 2240,2250,2260
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```
2240  VTAB 10: INPUT "  1.  BULLS: ->";HOLD$
2241  GOSUB 400
2242  IF BUM THEN 2245
2243 BB =  VAL (HOLD$)
2244  GOTO 2208
2245  GOSUB 500
2246  IF EXIT THEN 2290
2247  GOSUB 200
2248  GOTO 2240
2250  VTAB 12: INPUT "  2.  COWS:  ->";HOLD$
2251  GOSUB 400
2252  IF BUM THEN 2255
2253 CD =  VAL (HOLD$)
2254  GOTO 2208
2255  GOSUB 500
2256  IF EXIT THEN 2290
2257  GOSUB 200
2258  GOTO 2250
2260  VTAB 14: INPUT "  3.  CALVES:->";HOLD$
2261  GOSUB 400
2262  IF BUM THEN 2265
2263 CF =  VAL (HOLD$)
2264  GOTO 2208
2265  GOSUB 500
2266  IF EXIT THEN 2290
2267  GOSUB 200
2268  GOTO 2260
2290  RETURN
2295  REM
2296  REM
2300  REM  SBR TO ALTER REPRODUCTIVE RATES
2302  REM
2304 OP$ = "REVIEWING REPRO RATES": HOME : GOSUB 600
2306  VTAB 5: HTAB 9: PRINT " AGE";: HTAB 19: PRINT "YOUNG PER"
2308  HTAB 9: PRINT "CLASS";: HTAB 20: PRINT "FEMALE": PRINT
2310  FOR I = UN TO DIX
2312  HTAB 12 -  FN D(I): PRINT I;: HTAB 25 -  FN D(RR(I)): PRINT RR(I)
2314  NEXT
2316  VTAB 22: PRINT "* TO REVISE     / TO DISPLAY    > TO EXIT"
2318  VTAB 20: PRINT "WHAT NEXT?  ";: GET HOLD$: PRINT
2320 BUM = UN: GOSUB 500
2322  IF  NOT BUM THEN 2330
2324  GOSUB 200: REM  BEEP
2326  GOTO 2318
2330  IF EXIT THEN 2390
2332  IF DSPLAY THEN 2306
2340  REM  BEGIN MODIFYING DATA
2342  FOR I = UN TO DIX
2344  VTAB 7 + I: HTAB 20: INPUT "->";HOLD$
2346  GOSUB 400: REM  CHECK FOR NUMERICAL
2348  IF  NOT BUM THEN 2366
2350  GOSUB 500: REM  FLOW CHECK
2352  IF  NOT BUM THEN 2360
2354  GOSUB 200: REM  BEEP
2356  GOTO 2344
2360  IF EXIT THEN 2390
2362  IF DSPLAY THEN 2304
2364  IF RESTART THEN 2340
2366 RR(I) =  VAL (HOLD$)
2370  NEXT
```

```
2380  GOTO 2304
2390  RETURN
2395  REM
2396  REM
2400  REM  SBR TO ALTER AGE DISTRIBUTION
2401  REM
2402 OP$ = "REVIEWING AGE DIST - BULLS": HOME : GOSUB 600
2403  VTAB 5: HTAB 9: PRINT " AGE";: HTAB 19: PRINT "PROPORTION"
2404  HTAB 9: PRINT "CLASS": PRINT :TTL = ZE
2405  FOR I = UN TO DIX
2406  HTAB 12 -  FN D(I): PRINT I;: HTAB 25 -  FN D(MD(I)): PRINT MD(I):TTL
 = TTL + MD(I)
2407  NEXT
2408  HTAB 25: PRINT "(TOTAL = ";TTL;")": VTAB 22: PRINT "* TO REVISE    /
TO DISPLAY   > TO EXIT"
2409  VTAB 20: PRINT "WHAT NEXT?  ";: GET HOLD$: PRINT
2410 BUM = UN: GOSUB 500
2411  IF  NOT BUM THEN 2414
2412  GOSUB 200: REM  BEEP
2413  GOTO 2409
2414  IF EXIT THEN 2440
2415  IF DSPLAY THEN 2402
2416  REM  BEGIN MODIFYING DATA
2417  FOR I = UN TO DIX
2418  VTAB 7 + I: HTAB 20: INPUT "->";HOLD$
2419  GOSUB 400: REM   CHECK FOR NUMERICAL
2420  IF  NOT BUM THEN 2428
2421  GOSUB 500: REM  FLOW CHECK
2422  IF  NOT BUM THEN 2425
2423  GOSUB 200: REM  BEEP
2424  GOTO 2418
2425  IF EXIT THEN 2440
2426  IF DSPLAY THEN 2402
2427  IF RESTART THEN 2416
2428 MD(I) =  VAL (HOLD$)
2430  NEXT
2440  REM  END OF MALES
2450  REM  BEGINNING OF FEMALES
2451  REM
2452 OP$ = "REVIEWING AGE DIST. - COWS": HOME : GOSUB 600
2453  VTAB 5: HTAB 9: PRINT " AGE";: HTAB 19: PRINT "PROPORTION"
2454  HTAB 9: PRINT "CLASS": PRINT :TTL = ZE
2455  FOR I = UN TO DIX
2456  HTAB 12 -  FN D(I): PRINT I;: HTAB 25 -  FN D(FD(I)): PRINT FD(I):TTL
 = TTL + FD(I)
2457  NEXT
2458  HTAB 25: PRINT "(TOTAL = ";TTL;")": VTAB 22: PRINT "* TO REVISE    /
TO DISPLAY   > TO EXIT"
2459  VTAB 20: PRINT "WHAT NEXT?  ";: GET HOLD$: PRINT
2460 BUM = UN: GOSUB 500
2461  IF  NOT BUM THEN 2464
2462  GOSUB 200: REM   BEEP
2463  GOTO 2459
2464  IF EXIT THEN 2490
2465  IF DSPLAY THEN 2452
2466  REM   BEGIN MODIFYING DATA
2467  FOR I = UN TO DIX
2468  VTAB 7 + I: HTAB 20: INPUT "->";HOLD$
2469  GOSUB 400: REM    CHECK FOR NUMERICAL
2470  IF  NOT BUM THEN 2478
```

```
2471  GOSUB 500: REM   FLOW CHECK
2472  IF  NOT BUM THEN 2475
2473  GOSUB 200: REM   BEEP
2474  GOTO 2468
2475  IF EXIT THEN 2490
2476  IF DSPLAY THEN 2452
2477  IF RESTART THEN 2466
2478 FD(I) =  VAL (HOLD$)
2480  NEXT
2490  RETURN
2495  REM
2496  REM
2500  REM  SBR TO ALTER MORTALITY FACTORS
2502  REM
2510 OP$ = "MORTALITY FACTORS": HOME : GOSUB 600
2512  VTAB 5: PRINT "HERE IS THE STATUS OF MORTALITY FACTORS:"
2514  VTAB 8: HTAB 7: PRINT "FACTOR";: HTAB 18: PRINT "DISTRIBUTION"
2516  PRINT
2518  PRINT "  1.  WOLVES";: HTAB 18: PRINT WP$(WOLFLAG)
2520  PRINT "  2.  TREATY";: HTAB 18: PRINT WP$(TFLAG)
2522  PRINT "  3.  WINTER";: HTAB 18: PRINT WP$(WEAFLAG)
2524  PRINT "  4.  BLACK BOX";: HTAB 18: PRINT WP$(BFLAG)
2526  PRINT "  5.  HUNTING";: HTAB 18: PRINT WP$(HUFLAG)
2528  VTAB 21: HTAB 12: PRINT "( > TO EXIT)"
2530  VTAB 17: CALL  - 868: PRINT "ENTER NUMBER OF FACTOR TO ALTER/CHECK: "
;: GET HOLD$: PRINT HOLD$
2532  IF HOLD$ = ">" THEN 2590
2534  GOSUB 400
2536  IF BUM THEN 2540
2538  IF  VAL (HOLD$) < 6 THEN 2550
2540  GOSUB 200: REM  BEEP
2542  GOTO 2530
2550  ON  VAL (HOLD$) GOSUB 4100,4200,4300,4400,4500
2580  GOTO 2510
2590  RETURN
2595  REM
2596  REM
2600  REM  SBR TO ALTER SINGLE PARAMETER VALUES
2602  REM
2603 LM = 0:WW = 40: GOSUB 300: REM  SET TO FULL SCREEN
2604 OP$ = "SINGLE PARAMETERS": HOME : GOSUB 600: REM   SET TITLE
2606  VTAB 5: HTAB 10
2608  PRINT "PARAMETER";: HTAB 30: PRINT "STATUS"
2609  HTAB 10
2610  PRINT "---------";: HTAB 30: PRINT "------"
2612  VTAB 7: PRINT "1. CONTINUOUS";: HTAB 32: PRINT YN$(CNT)
2614  PRINT "2. CALVES BORN: MALES/TOTAL";: HTAB 32: PRINT MPRCNT
2616  PRINT "3. CALVES: 6 MONTHS/BORN";: HTAB 32: PRINT  FN B(PSTNT)
2618  PRINT "4. UNRETRIEVED/RETRIEVED ";: HTAB 32: PRINT URKILL
2620  PRINT "5. HUNTING KILL: CALVES/TOTAL";: HTAB 32: PRINT HCPRCNT
2622  PRINT "6. HUNTING: MALES KILLED";: HTAB 32: PRINT HM
2624  PRINT "7. HUNTING: FEMALES KILLED";: HTAB 32: PRINT HF
2626  PRINT "8. WOLVES: TOTAL KILL";: HTAB 32: PRINT WKILL
2628  PRINT "9. TREATY HARVEST: TOTAL KILL";: HTAB 32: PRINT TKILL
2630  PRINT "10.WINTER WEATHER: TOTAL KILL";: HTAB 32: PRINT KWNTR
2632  PRINT "11.BLACK BOX: TOTAL KILL";: HTAB 32: PRINT BKILL
2634  PRINT "12.STARTING YEAR";: HTAB 32: PRINT SYEAR
2636  PRINT "13.YEARS OF SIMULATION";: HTAB 32: PRINT TYEARS
2637  PRINT "14.PAUSE AFTER EACH YEAR?";: HTAB 32: PRINT YN$(YPFLAG)
2638  PRINT "0. NO FURTHER CHANGES"
```

```
2640  PRINT : INPUT "ENTER THE NUMBER OF YOUR CHOICE. ";RESP$
2642 HOLD$ = RESP$: GOSUB 400
2644  IF  NOT BUM THEN 2649
2646  GOSUB 200: REM  BEEP
2648  GOTO 2602
2649  IF  VAL (RESP$) < 15 THEN 2652
2650  GOSUB 200: REM  BEEP
2651  GOTO 2602
2652 LINE =  VAL (RESP$): IF LINE = 0 THEN 2690
2654 LM = 30:WW = 9: GOSUB 300: REM   RESET WINDOW TO DATA PORTION OF SCREE
N
2656  GOSUB 2700
2658  ON LINE GOTO 2660,2662,2664,2666,2668,2670,2672,2674,2676,2678,2680,2
682,2683,2686
2660 CNT = 0: IF  LEFT$ (RESP$,1) = "Y" THEN CNT = 1
2661  GOTO 2602
2662 MPRCNT =  VAL (RESP$): GOTO 2602
2664 PSTNT =  VAL (RESP$): GOTO 2602
2666 URKILL =  VAL (RESP$): GOTO 2602
2668 HCPRCNT =  VAL (RESP$): GOTO 2602
2670 HM =  VAL (RESP$): GOTO 2602
2672 HF =  VAL (RESP$): GOTO 2602
2674 WKILL =  VAL (RESP$): GOTO 2602
2676 TKILL =  VAL (RESP$): GOTO 2602
2678 KWNTR =  VAL (RESP$): GOTO 2602
2680 BKILL =  VAL (RESP$): GOTO 2602
2682 SYEAR =  VAL (RESP$): GOTO 2602
2683  IF ( VAL (RESP$) > 8) THEN  GOSUB 200: REM  BEEP
2684  IF ( VAL (RESP$) > 8) THEN  GOTO 2602
2685 TYEARS =  VAL (RESP$): GOTO 2602
2686 YPFLAG = 0: IF  LEFT$ (RESP$,1) = "Y" THEN YPFLAG = 1
2688  GOTO 2602
2690  RETURN
2695  REM
2696  REM
2700  REM  SBR TO PICK A SINGLE PARAMETER
2702  REM
2704  VTAB 6 +  VAL (RESP$): CALL  - 868: INPUT "->";RESP$
2790  RETURN
2795  REM
2796  REM
2800  REM   SBR TO DISTRIBUTE POPULATION ACCORDING TO AGE DISTRIBUTION PROP
ORTIONS AND TO SET GRAPHICS PARAMETERS
2802  REM
2804 MA(UN) = MPRCNT * CF:FE(UN) = CF - MA(UN)
2806  FOR I = DE TO DI:MA(I) = BB * MD(I):FE(I) = CD * FD(I): NEXT
2810 ST(1) =  INT (BB):ST(2) =  INT (CD):ST(3) =  INT (CF):OM(0,1,1) = ST(1
):OM(0,1,2) = ST(2):OM(0,1,3) = ST(3)
2820  FOR J = UN TO 3
2822 OM(0,9,J) = OM(0,1,J)
2824  NEXT J
2826 OM(0,9,4) = OM(0,9,1) + OM(0,9,2) + OM(0,9,3):OM(0,1,4) = OM(0,9,4)
2850  REM  SET GRAPHICS PARAMETERS
2852 MXP = 500 * (1 +  INT (OM(0,9,4) / 500)): REM   THIS IS THE HEIGHT OF
THE GRAPHICS SCREEN
2854  IF MXP < 500 THEN MXP = 500
2890  RETURN
2895  REM
2896  REM
2900  REM  SBR TO SUMMARIZE THE YEAR'S SIMULATION
```

```
2902  REM
2904 OP$ = "SUMMARY OF " +  STR$ (CYEAR)
2906  HOME : GOSUB 600: REM  TITLE
2907  VTAB 5: HTAB 15: PRINT "BULLS  COWS CALVES ";: INVERSE : PRINT "TOTAL
": NORMAL
2908  PRINT : INVERSE : PRINT "YEAR START:";: NORMAL
2910  HTAB 20 -  FN D(OM(PL,1,1)): PRINT OM(PL,1,1);: HTAB 26 -  FN D(OM(PL
,1,2)): PRINT OM(PL,1,2);: HTAB 33 -  FN D(OM(PL,1,3)): PRINT OM(PL,1,3);:
HTAB 39 -  FN D(OM(PL,1,4)): INVERSE : PRINT OM(PL,1,4): NORMAL
2911  PRINT "MEAN AGES   MALES: "; FN B(ZMMAGE);"  FEMALES:  "; FN B(ZFMAGE
)
2912  PRINT
2914  PRINT "LOSSES TO:"
2916  FOR I = DEUX TO 7
2918  HTAB 20 -  FN D(OM(PL,I,1)): PRINT OM(PL,I,1);: HTAB 26 -  FN D(OM(PL
,I,2)): PRINT OM(PL,I,2);: HTAB 33 -  FN D(OM(PL,I,3)): PRINT OM(PL,I,3);:
HTAB 39 -  FN D(OM(PL,I,4)): PRINT OM(PL,I,4)
2920  NEXT I
2930  VTAB 11: HTAB 3: PRINT "WOLVES"
2932  HTAB 3: PRINT "TREATY KILL"
2934  HTAB 3: PRINT "WINTER KILL"
2936  HTAB 3: PRINT "BLACK BOX"
2938  HTAB 3: PRINT "SPORT KILL"
2940  HTAB 3: PRINT "POSTNATAL"
2942  PRINT
2944  HTAB 3: PRINT "TOTALS";
2950  HTAB 20 -  FN D(OM(PL,8,1)): PRINT OM(PL,8,1);: HTAB 26 -  FN D(OM(PL
,8,2)): PRINT OM(PL,8,2);: HTAB 33 -  FN D(OM(PL,8,3)): PRINT OM(PL,8,3);:
HTAB 39 -  FN D(OM(PL,8,4)): PRINT OM(PL,8,4)
2952  PRINT
2960  INVERSE : PRINT "YEAR END:";: NORMAL
2962  HTAB 20 -  FN D(OM(PL,9,1)): PRINT OM(PL,9,1);: HTAB 26 -  FN D(OM(PL
,9,2)): PRINT OM(PL,9,2);: HTAB 33 -  FN D(OM(PL,9,3)): PRINT OM(PL,9,3);:
HTAB 39 -  FN D(OM(PL,9,4)): INVERSE : PRINT OM(PL,9,4): NORMAL
2963  PRINT "MEAN AGES   MALES: "; FN B(MMAGE);"  FEMALES:  "; FN B(FMAGE)
2964  PRINT "CALVES/100 COWS ...AT BIRTH:  "; TAB( 37 -  LEN ( STR$ ( INT (
CC(1)))));CC(1)
2966  PRINT "                    ...6 MONTHS:  ";: HTAB 37 -  LEN ( STR$ ( INT
(CC(2))));: PRINT CC(2)
2970  IF  NOT YPFLAG THEN 2983
2980  PRINT "PRESS ANY KEY TO CONTINUE: ";: GET A$: PRINT A$
2982  GOTO 2984
2983  FOR ZPAUSE = 1 TO 1000: NEXT ZPAUSE
2984  IF ANNFLAG = 0 THEN 2986
2985  GOSUB 3600: REM  ANNUAL PRINTOUT
2986  GOSUB 900: REM  GRAPHICS DISPLAY
2990  RETURN
2995  REM
2996  REM
3000  REM  SBR TO GET 20 VALUES IN A PAIR OF VECTORS, EACH WITH 10 VALUES
3002  REM
3004  REM  THE TEMPORARY STORAGE VECTORS ARE VM (MALES) AND VF (FEMALES)
3006 OP$ = OP$ + "-MALES"
3008  FOR I = UN TO DIX:VX(I) = VM(I): NEXT : REM  PUT MALE VALUES INTO TEM
PORARY VECTOR VX
3010  GOSUB 3100: REM  GET VECTOR FOR MALES
3012  FOR I = UN TO DIX:VM(I) = VX(I): NEXT : REM  PUT REVISED VALUES BACK
INTO MALE STORAGE VECTOR
3014 OP$ =  LEFT$ (OP$,( LEN (OP$) - 6)): REM  STRIP THE LAST 6 CHARACTERS
3016 OP$ = OP$ + "-FEMALES"
```

```
3018  FOR I = UN TO DIX:VX(I) = VF(I): NEXT : REM  SAME FOR FEMALES
3020  GOSUB 3100: REM  GET VECTOR FOR FEMALES
3022  FOR I = UN TO DIX:VF(I) = VX(I): NEXT : REM  STUFF NEW VALUES BACK IN
TO FEMALE STORAGE VECTOR
3090  RETURN
3095  REM
3096  REM
3100  REM  SBR TO PUT 10 VALUES INTO THE TEMPORARY VECTOR VX
3102  REM
3104  HOME : GOSUB 600
3106  VTAB 5: HTAB 9: PRINT " AGE";: HTAB 20: PRINT "WEIGHT"
3108  HTAB 9: PRINT "CLASS": PRINT
3109 TTL = ZE
3110  FOR I = UN TO DIX
3112  HTAB 12 -  FN D(I): PRINT I;: HTAB 25 -  FN D( FN B(VX(I))): PRINT  F
N C(VX(I))
3113 TTL = TTL + VX(I)
3114  NEXT
3115  HTAB 25: PRINT "(TOTAL = ";TTL;")"
3116  VTAB 22: PRINT "* TO REVISE   / TO DISPLAY   > TO EXIT"
3118  VTAB 20: PRINT "WHAT NEXT?  ";: GET HOLD$: PRINT
3120 BUM = UN: GOSUB 500
3122  IF  NOT BUM THEN 3130
3124  GOSUB 200: REM  BEEP
3126  GOTO 3118
3130  IF EXIT THEN 3190
3132  IF DSPLAY THEN 3106
3140  REM   BEGIN MODIFYING DATA
3142  FOR I = UN TO DIX
3144  VTAB 7 + I: HTAB 20: INPUT "->";HOLD$
3146  GOSUB 400: REM   CHECK FOR NUMERICAL
3148  IF  NOT BUM THEN 3166
3150  GOSUB 500: REM   FLOW CHECK
3152  IF  NOT BUM THEN 3160
3154  GOSUB 200: REM   BEEP
3156  GOTO 3144
3160  IF EXIT THEN 3190
3162  IF DSPLAY THEN 3104
3164  IF RESTART THEN 3140
3166 VX(I) =  VAL (HOLD$)
3170  NEXT
3180  GOTO 3104
3190  RETURN
3195  REM
3196  REM
3200  REM  SBR TO CHANGE POSTNATAL MORTALITY
3202  REM
3204  PRINT "THE CALVES/100 COWS WILL BE:  "; INT (100 * (CALVES * PSTNT) /
 CD)
3206  PRINT "WHEN CALVES ARE SIX MONTHS OLD."
3208  CALL  - 958: INPUT "WANT TO CHANGE IT?  (Y/N) "IA$
3210  IF  LEN (A$) = 1 THEN 3218
3212  GOSUB 200: REM  BEEP
3214  VTAB ( PEEK (37)): GOTO 3208
3218  IF A$ = "N" THEN 3290
3219  IF A$ <  > "Y" THEN 3212
3220  INPUT "NEW CALVES/100 COWS AT SIX MONTHS: "ICC
3222 PSTNT = CC / CC(1)
3290  RETURN
3295  REM
```

```
3296  REM
3300  REM  SBR TO HANDLE ERRORS
3301  TEXT : HOME
3302  REM
3303 LM = 0:WW = 40: GOSUB 300: REM  RESET FULL SCREEN
3304 EC =  PEEK (222): REM  ERROR CODE
3306 OP$ = "ERROR HANDLING"
3308  HOME : GOSUB 600: REM  TITLE
3309  IF EC = 255 THEN 3390
3310  VTAB 5
3312  PRINT "CONGRATULATIONS, PAL."
3314  PRINT : PRINT "ONE OR BOTH OF THE FOLLOWING HAS/HAVE "
3316  PRINT "HAPPENED:   "
3318  PRINT : PRINT : PRINT "1.  YOU SCREWED UP."
3320  PRINT : PRINT "2.  I SCREWED UP."
3322  PRINT : PRINT "IN ORDER TO ALLOW ME TO TRACK DOWN THE"
3324  PRINT "SCREWUP (AND THE PERSON RESPONSIBLE)"
3326  PRINT "PLEASE WRITE DOWN THE CIRCUMSTANCES"
3328  PRINT "PRECEDING THE BUNGLE, AND THE FOLLOWING"
3330  PRINT "NUMBER:          ";EC;" ."
3332  PRINT "THIS IS THE ERROR CODE FOR WHAT YOU/I"
3334  PRINT "JUST DID.  TO CARRY ON, PRESS ANY KEY."
3338  GET A$: PRINT A$
3390  GOTO 7012
3395  REM
3396  REM
3400  REM  SBR TO ASSEMBLE OUTPUT MATRIX FOR A YEAR
3402  REM
3404  REM  ROW 1 HAS ALREADY BEEN FILLED WITH THE DATA FROM THE BEGINNING O
F THE YEAR
3406  FOR J = UN TO 3
3408 PL = 1 + CYEAR - SYEAR
3410 OM(PL,DE,J) =  INT (WLOSS(J))
3412 OM(PL,3,J) =  INT (TLOSS(J))
3414 OM(PL,4,J) =  INT (WEALOSS(J))
3416 OM(PL,5,J) =  INT (BLOSS(J))
3418 OM(PL,6,J) =  INT (HLOSS(J))
3420  NEXT J
3422 OM(PL,7,3) =  INT (PNLOSS)
3424 OM(PL,9,UN) =  INT (BB):OM(PL,9,DE) =  INT (CD):OM(PL,9,3) =  INT (CF)

3426  FOR J = UN TO 3
3428  FOR I = DEUX TO 7
3430 OM(PL,8,J) = OM(PL,8,J) + OM(PL,I,J)
3432  NEXT I
3434  NEXT J
3436  FOR I = UN TO 9
3438 OM(PL,I,4) = OM(PL,I,1) + OM(PL,I,2) + OM(PL,I,3)
3440  NEXT I
3490  RETURN
3495  REM
3496  REM
3500  REM   SBR TO PRINT A SUMMARY TABLE OF A COMPLETED SIMULATION
3502  REM
3504 OP$ = "PRINTOUT": HOME : GOSUB 600: REM  SET TITLE
3506  PR# 1
3508  PRINT  CHR$ (12): REM   FORM FEED
3510  FOR I = 1 TO 15: PRINT : NEXT I
3512  PRINT  TAB( 2);"THIS IS A SUMMARY OF THE SIMULATION"
3514  PRINT  TAB( 2);"----------------------------------"
```

```
3516  PRINT
3520  PRINT "YEAR *         BULLS  COWS CALVES TOTAL"
3522  PRINT "-----          -----  ---- ------ -----"
3526  FOR PL = 0 TO TYEARS
3530  PRINT SYEAR + PL; TAB( 20 -  FN D(OM(PL,9,1)));OM(PL,9,1); TAB( 26 -
 FN D(OM(PL,9,2)));OM(PL,9,2); TAB( 33 -  FN D(OM(PL,9,3)));OM(PL,9,3); TAB
( 39 -  FN D(OM(PL,9,4)));OM(PL,9,4)
3540  NEXT PL
3550  PRINT : PRINT "  * ALL NUMBERS ARE AS OF 1 JANUARY "
3580  PR# 0
3590  RETURN
3595  REM
3596  REM
3600  REM  SBR TO PRINT THE RESULTS OF ONE YEAR'S SIMULATION
3602  REM
3604 OP$ = "PRINTING          ": GOSUB 600: REM   SET TITLE
3606  VTAB 23: HTAB 38
3607  PR# 1
3608  IF PL > 1 THEN 3610
3609  PRINT  CHR$ (12): REM  FORM FEED
3610  PRINT : PRINT
3612  PRINT TITLE$;":    SUMMARY OF "; STR$ (CYEAR)
3613  FOR I = 1 TO (20 +  LEN (TITLE$)): PRINT "-";: NEXT I
3614  PRINT : PRINT
3616  PRINT  TAB( 15);"BULLS  COWS CALVES TOTAL"
3618  PRINT : PRINT "YEAR START:";
3620  PRINT  TAB( 20 -  FN D(OM(PL,1,1)));OM(PL,1,1); TAB( 26 -  FN D(OM(PL
,1,2)));OM(PL,1,2); TAB( 33 -  FN D(OM(PL,1,3)));OM(PL,1,3); TAB( 39 -  FN
D(OM(PL,1,4)));OM(PL,1,4)
3622  PRINT "MEAN AGES   MALES: "; FN B(ZMMAGE);"  FEMALES:  "; FN B(ZFMAGE
)
3624  PRINT
3626  PRINT "LOSSES TO:"
3628  FOR I = DEUX TO 7
3630  PRINT "   ";ML$(I); TAB( 20 -  FN D(OM(PL,I,1)));OM(PL,1,1); TAB( 26
-  FN D(OM(PL,I,2)));OM(PL,I,2); TAB( 33 -  FN D(OM(PL,I,3)));OM(PL,I,3); T
AB( 39 -  FN D(OM(PL,I,4)));OM(PL,I,4)
3632  NEXT I
3634  PRINT : HTAB 3: PRINT "TOTALS";
3636  PRINT  TAB( 20 -  FN D(OM(PL,8,1)));OM(PL,8,1); TAB( 26 -  FN D(OM(PL
,8,2)));OM(PL,8,2); TAB( 33 -  FN D(OM(PL,8,3)));OM(PL,8,3); TAB( 39 -  FN
D(OM(PL,8,4)));OM(PL,8,4)
3638  PRINT : PRINT "YEAR END:";
3640  PRINT  TAB( 20 -  FN D(OM(PL,9,1)));OM(PL,9,1); TAB( 26 -  FN D(OM(PL
,9,2)));OM(PL,9,2); TAB( 33 -  FN D(OM(PL,9,3)));OM(PL,9,3); TAB( 39 -  FN
D(OM(PL,9,4)));OM(PL,9,4)
3642  PRINT "MEAN AGES   MALES: "; FN B(MMAGE);"  FEMALES:  "; FN B(FMAGE)
3644  PRINT "CALVES/100 COWS ...AT BIRTH:  "; TAB( 37 -  LEN ( STR$ ( INT (
CC(1)))));CC(1)
3646  PRINT "                  ...6 MONTHS:  "; TAB( 37 -  LEN ( STR$ ( INT (
CC(2)))));CC(2)
3647  IF FFFLAG = 1 THEN 3680
3648  PRINT : PRINT
3650  PRINT "                *****"
3656  PRINT : PRINT
3680 FFFLAG = FFFLAG + 1
3682  IF FFFLAG = 1 THEN 3688
3684  PRINT  CHR$ (12): REM  FORM FEED
3686 FFFLAG = 0
3688  PR# 0
```

```
3690  RETURN
3695  REM
3696  REM
3700  REM  SBR TO SET PRINTOUT PARAMETERS
3702  REM
3704 OP$ = "SETTING PRINTOUT PARAMETERS": HOME : GOSUB 600: REM  SET TITLE
3705  VTAB 20: HTAB 1: PRINT "IF YOU HAVE SET THESE PARAMETERS DURING": PRI
NT " A PREVIOUS RUN AND WANT TO LEAVE THEM": PRINT "       UNCHANGED, JUST E
NTER  >"
3706  VTAB 5: PRINT "DO YOU WANT A TITLE PAGE PRINTED? (Y/N)";: GET HOLD$:
PRINT HOLD$
3707  IF HOLD$ = ">" THEN 3790
3708  IF HOLD$ = "Y" THEN TPFLAG = 1
3710  IF HOLD$ = "N" THEN TPFLAG = 0
3712  IF HOLD$ = "Y" OR HOLD$ = "N" THEN 3720
3714  GOSUB 200: REM  BEEP
3715  VTAB ( PEEK (37)): CALL  - 868
3716  GOTO 3706
3720  VTAB 7: PRINT "DO YOU WANT AN ANNUAL PRINTOUT?   (Y/N)";: GET HOLD$:
PRINT HOLD$
3722  IF HOLD$ = ">" THEN 3790
3724  IF HOLD$ = "Y" THEN ANNFLAG = 1
3726  IF HOLD$ = "N" THEN ANNFLAG = 0
3728  IF HOLD$ = "Y" OR HOLD$ = "N" THEN 3740
3730  GOSUB 200: REM  BEEP
3732  VTAB ( PEEK (37)): CALL  - 868
3734  GOTO 3720
3740  REM  NEXT
3790  RETURN
3795  REM
3796  REM
3800  REM  SBR TO PRINT TITLE PAGE OF SIMULATION
3802  REM
3804  IF TPFLAG = 0 THEN 3890
3806  PR# 1
3810  PRINT  CHR$ (12): REM  FORM FEED
3812  PRINT : PRINT
3813  PRINT  TAB( 15)"*********************************************": PRINT
TAB( 15)"*                                           *"
3814  PRINT  TAB( 15)"*   GENERAL UNGULATE MODEL, VERSION 1.0   *": PRINT
TAB( 15)"*                                           *"
3815  PRINT  TAB( 15)"*********************************************"
3816  PRINT : PRINT : PRINT
3817  PRINT "SPECIES:"
3818  PRINT  TAB( 25)"------------------------------------"
3820  PRINT "NAME OF HERD:"
3821  PRINT  TAB( 25)"------------------------------------"
3822  PRINT "DATE:"
3823  PRINT  TAB( 25)"------------------------------------"
3824  PRINT "USER:"
3825  PRINT  TAB( 25)"------------------------------------"
3826  PRINT "TITLE:";
3827  PRINT  TAB( 25)TITLE$
3828  PRINT  TAB( 25)"------------------------------------": PRINT
3830  FOR I = 1 TO 75
3831  PRINT "=";
3832  NEXT I
3834  PRINT : PRINT
3836  PRINT "PARAMETERS AS SET FOR THIS RUN:  ": PRINT
3838  PRINT  TAB( 5)"CONTINUOUS APPLICATION OF THE SAME MORTALITY RATES?";
```

```
TAB( 34 -  LEN (YN$(CNT)))YN$(CNT)
3840  PRINT  TAB( 5)"STARTING YEAR:  "; TAB( 70)SYEAR
3842  PRINT  TAB( 5)"NUMBER OF YEARS:"; TAB( 73)TYEARS: PRINT
3843  PRINT  TAB( 5)"PROPORTION OF THE CALF CROP (AT BIRTH) WHICH IS MALE:
      "; MPRCNT
3844  PRINT  TAB( 5)"PROBABILITY OF SURVIVING FIRST SIX MONTHS OF LIFE:
      "; FN B(PSTNT)
3846  PRINT  TAB( 5)"UNRETRIEVED KILL, AS A PROPORTION OF RETRIEVED KILL:
      "; URKILL: PRINT
3848  PRINT  TAB( 5)"APPLICATION OF MORTALITY FROM:": PRINT
3850  PRINT  TAB( 35)"WOLVES:"; TAB( 22)WP$(WOLFLAG)
3852  PRINT  TAB( 35)"TREATY:"; TAB( 22)WP$(TFLAG)
3854  PRINT  TAB( 35)"WINTER:"; TAB( 22)WP$(WEAFLAG)
3856  PRINT  TAB( 35)"BLACK BOX:"; TAB( 22)WP$(BFLAG)
3858  PRINT  TAB( 35)"SPORT HUNTING:"; TAB( 22)WP$(HUFLAG)
3860  PRINT
3880  FOR I = 1 TO 75
3881  PRINT "=";
3882  NEXT I
3883  PRINT : PRINT
3884  PRINT "COMMENTS:": PRINT "--------": PRINT
3885  FOR I = 1 TO 5: PRINT "------------------------------------------------
------------------------------": NEXT I
3888  PR# 0
3890  RETURN
3895  REM
3896  REM
4100  REM  SBR TO ALTER MORTALITY FROM WOLF PREDATION
4102  REM
4104 OP$ = "WOLF PREDATION"
4105  GOSUB 700: REM  SET FLAG
4106 WOLFLAG =  VAL (A$)
4108  IF WOLFLAG <  > 1 THEN 4190
4110  FOR I = UN TO DIX:VM(I) = WM(I):VF(I) = WF(I): NEXT
4112  GOSUB 3000: REM  ALTER/CHECK WEIGHTS
4113 TCHK = ZE
4114  FOR I = UN TO DIX:WM(I) = VM(I):WF(I) = VF(I):TCHK = TCHK + WM(I) + W
F(I): NEXT
4190  RETURN
4200  REM  SBR TO ALTER MORTALITY FROM TREATY INDIAN HARVEST
4202  REM
4204 OP$ = "TREATY HARVEST"
4205  GOSUB 700: REM  SET FLAG
4206 TFLAG =  VAL (A$)
4208  IF TFLAG <  > 1 THEN 4290
4210  FOR I = UN TO DIX:VM(I) = TMWT(I):VF(I) = TFWT(I): NEXT
4212  GOSUB 3000: REM  ALTER/CHECK WEIGHTS
4214  FOR I = UN TO DIX:TMWT(I) = VM(I):TFWT(I) = VF(I): NEXT
4290  RETURN
4300  REM  SBR TO ALTER MORTALITY FROM WINTER WEATHER
4302  REM
4304 OP$ = "WINTER MORTALITY"
4305  GOSUB 700: REM  SET FLAG
4306 WEAFLAG =  VAL (A$)
4308  IF WEAFLAG <  > 1 THEN 4390
4310  FOR I = UN TO DIX:VM(I) = MWTH(I):VF(I) = FWTH(I): NEXT
4312  GOSUB 3000: REM  ALTER/CHECK WEIGHTS
4314  FOR I = UN TO DIX:MWTH(I) = VM(I):FWTH(I) = VF(I): NEXT
4390  RETURN
4400  REM  SBR TO ALTER MORTALITY FROM BLACK BOX MORTALITY
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```
4402  REM
4404 OP$ = "BBOX MORTALITY"
4405  GOSUB 700: REM  SET FLAG
4406 BFLAG =  VAL (A$)
4408  IF BFLAG <  > 1 THEN 4490
4410  FOR I = UN TO DIX:VM(I) = MBBOX(I):VF(I) = FBBOX(I): NEXT
4412  GOSUB 3000: REM  ALTER/CHECK WEIGHTS
4414  FOR I = UN TO DIX:MBBOX(I) = VM(I):FBBOX(I) = VF(I): NEXT
4490  RETURN
4500  REM  SBR TO ALTER MORTALITY FROM HUNTING
4502  REM
4504 OP$ = "HUNTING MORTALITY"
4505  GOSUB 700: REM  SET FLAG
4506 HUFLAG =  VAL (A$)
4508  IF HUFLAG <  > 1 THEN 4590
4510  FOR I = UN TO DIX:VM(I) = MHUNT(I):VF(I) = FHUNT(I): NEXT
4512  GOSUB 3000: REM  ALTER/CHECK WEIGHTS
4514  FOR I = UN TO DIX:MHUNT(I) = VM(I):FHUNT(I) = VF(I): NEXT
4590  RETURN
5000  REM    BEGIN MAIN PROGRAM - CHECK FOR ALTERING SOME COMPONENTS
5002 TITLE$ = "GHA 18"
5003  GOSUB 3700: REM  SET PRINTOUT PARAMETERS
5004  GOSUB 2000: REM  MAIN SETUP MENU
5005  GOSUB 2800: REM  DISTRIBUTE AMONG AGE CLASSES'
5006  GOSUB 3800: REM  PRINT TITLE PAGE
5007  FOR CYEAR = SYEAR TO (SYEAR + TYEARS - 1)
5008 OP$ = "EXECUTING " +  STR$ (CYEAR): HOME : GOSUB 600: REM  TITLE
5010 PL = 1 + CYEAR - SYEAR
5012 OM(PL,1,1) =  INT (BB):OM(PL,1,2) =  INT (CD):OM(PL,1,3) =  INT (CF)
5014 OM(PL,1,4) = 0
5016  FOR I = UN TO 3:OM(PL,1,4) = OM(PL,1,4) + OM(PL,1,I): NEXT I
5020  GOSUB 800: REM  DISPLAY STATUS
5021  PRINT
5022  PRINT "ANNUAL CYCLE:"
5023  PRINT "-------------"
5024  IF WOLFLAG = 3 THEN 5027: REM  CHECK FOR DELETION OF WOLF MORTALITY
5025  GOSUB 1000: REM  WOLVES
5027  REM
5029  IF TFLAG = 3 THEN 5032: REM  CHECK FOR DELETION OF TREATY MORTALITY
5030  GOSUB 1100: REM  TREATY
5032  REM
5034  IF WEAFLAG = 3 THEN 5037: REM  CHECK FOR DELETION OF WINTER MORTALITY

5035  GOSUB 1200: REM  WINTER
5037  REM
5040  GOSUB 1800: REM  REPRODUCTION
5045  GOSUB 1900: REM  POSTNATAL
5049  IF HUFLAG = 3 THEN 5052: REM  CHECK FOR DELETION OF HUNTING
5050  GOSUB 1400: REM  HUNTING
5052  REM
5054  IF BFLAG = 3 THEN 5057: REM  CHECK FOR DELETION OF BLACK BOX MORTALIT
Y
5055  GOSUB 1300: REM  BLACK BOX
5057  REM
5070  GOSUB 3400: REM  ASSEMBLE DATA INTO CORRECT PLANE OF OUTPUT MATRIX
5080  GOSUB 2900: REM  YEAREND SUMMARY
5090  NEXT CYEAR
6000  VTAB 24: FLASH : PRINT "DONE.  WANT RESULTS PRINTED?  (Y/N)";: NORMAL

6001  FOR I = 1 TO 5
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```
6002  GOSUB 200: REM  BEEP
6003  NEXT I
6005  GET A$: PRINT A$: TEXT : HOME
6006  IF A$ = "Y" THEN 6010
6007  IF A$ = "N" THEN 7000
6008  GOSUB 200: REM  BEEP
6009  GOTO 6000
6010  GOSUB 3500: REM  PRINT RESULTS
7000 OP$ = "PRINTOUT COMPLETED": HOME : GOSUB 600: REM  TITLE
7008  VTAB 10: HTAB 5: PRINT "ANOTHER RUN  (Y/N)?  "; : GET A$: PRINT A$
7010  IF A$ = "N" THEN 7080
7011  IF A$ <  > "Y" THEN 7000
7012 OP$ = "RESETTING VARIABLES": HOME : GOSUB 600: REM  TITLE
7013  VTAB 10: HTAB 7: PRINT "VARIABLES ARE BEING RESET": PRINT : HTAB 3: P
RINT "(THIS WILL TAKE ABOUT 15 SECONDS)"
7014  VTAB 23
7015 BB = ST(1):CD = ST(2):CF = ST(3):MA = ST(4):FE = ST(5)
7016  FOR PL = 0 TO 10
7017  FOR I = 1 TO 9
7018  FOR J = 1 TO 4
7020 OM(PL,I,J) = ZE: REM  RESET THE OUTPUT MATRIX TO ZERO
7022  NEXT J
7024  NEXT I
7026  NEXT PL
7030  REM  RESET INDIVIDUAL COUNTERS OF LOSSES TO MORTALITY FACTORS
7032  FOR I = UN TO 3
7034 WLOSS(I) = ZE:TLOSS(I) = ZE:WEALOSS(I) = ZE:BLOSS(I) = ZE:HLOSS(I) = Z
E
7036  NEXT I
7038 FFFLAG = 0
7050  GOTO 5000
7060 OP$ = "LAST CHANCE": HOME : GOSUB 600: REM  TITLE
7082  VTAB 8
7084  PRINT "  I HOPE YOU WROTE DOWN EVERYTHING"
7085  PRINT "  FROM THESE RUNS THAT YOU'LL NEED."
7086  VTAB 18
7087  PRINT : PRINT "IF YOU REALLY WANT TO QUIT, PRESS Q.": PRINT : PRINT "
  ANY OTHER KEY SAVES YOUR BACON."
7088  PRINT : PRINT "->"; : GET A$: PRINT A$
7089  IF A$ <  > "Q" THEN 7000
7090  HOME : VTAB 10: HTAB 14: PRINT "MILLER TIME"
7098  VTAB 22
7099  END
```